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Summary and Implications

Two experiments were conducted to determine the efficiency of utilization of crystalline lysine relative to the lysine in soybean meal for growth in barrows and gilts fed individually or in groups. One hundred twelve growing pigs (56 barrows and 56 gilts; average initial body weight of 39.6 lb) were used in each experiment. Pigs were fed individually (I) or in groups of three (G). There were 28 individually penned and 84 in 28 pens with three pigs/pen). There were two replications per treatment in each experiment for a total of four replications. For the 28-day experiments, pigs were fed one of seven dietary treatments in both experiments. Dietary treatments consisted of a basal diet (0.55% lysine) and diets containing 0.65, 0.75, and 0.85% lysine that were achieved by adding lysine to the basal diet from either soybean meal (SBM) or L-lysine•HCl (crystalline). Average daily (ADG), average daily feed intake (ADFI), and feed efficiency (ADG/ADFI) were recorded. Total lysine intake (TLI) and supplemental lysine intake (SLI) were calculated. At the end of the experiments, all pigs were scanned using real-time ultrasound to determine tenth-rib backfat depth and longissimus muscle area (LMA) to calculate fat-free lean gain (FFLG). Blood samples were taken from all pigs weekly to determine plasma urea concentration (PUC). Growth performance was similar between pigs fed crystalline lysine or SBM. Average daily gain was affected by dietary lysine concentration ($P < 0.01$) but was similar for both sources of lysine. Pigs fed individually had a greater ADG than pigs fed in groups ($P < 0.05$). No differences among dietary treatments ($P > 0.10$) were observed in ADFI. However, pigs fed individually had a greater ADFI ($P < 0.05$) than pigs fed in groups. Feed efficiency improved as the lysine concentration in the diet increased ($P < 0.01$). Backfat depth was similar among treatments ($P > 0.10$), and LMA increased ($P < 0.01$) as the lysine concentration increased for both sources of lysine. Gilts had a greater LMA ($P < 0.01$) than barrows. Fat-free lean gain increased ($P < 0.01$) as dietary lysine

Table 1. Composition of diets, as-fed basis.

Diets:	BASAL	CRYSTALLINE			SOYBEAN MEAL		
Lysine, %:	0.55	0.65	0.75	0.85	0.65	0.75	0.85
Ingredient, %							
Corn	52.44	52.44	52.44	52.44	52.44	52.44	52.44
Cornstarch	13.00	12.61	12.23	11.85	9.64	6.33	2.97
Soybean meal, 46.5% CP	7.50	7.50	7.50	7.50	10.80	14.10	17.40
Sunflower meal	21.20	21.50	21.50	21.50	21.50	21.50	21.50
Tallow	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Dicalcium phosphate	2.20	2.20	2.20	2.20	2.10	1.95	1.85
Limestone	0.47	0.47	0.47	0.47	0.50	0.55	0.57
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Vitamin premix[a]	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Trace mineral premix[b]	0.15	0.15	0.15	0.15	0.15	0.15	0.15
L-Lysine•HCl		0.13	0.26	0.39			
L-tryptophan	0.05	0.08	0.12	0.14	0.06	0.07	0.08
L-threonine	0.10	0.23	0.33	0.46	0.17	0.21	0.28
DL-methionine	0.07	0.19	0.29	0.39	0.14	0.20	0.25
Nutrient Composition[c]							
Crude protein, %	14.80	14.90	15.00	15.40	16.30	17.80	19.30
Lysine, %	0.55	0.65	0.75	0.85	0.65	0.75	0.85
Calcium, %	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Phosphorus, %	0.60	0.60	0.60	0.60	0.60	0.60	0.60
ME[d], Mcal/lb	1.38	1.37	1.36	1.35	1.37	1.36	1.35

[a]Supplied per kilogram of diet: retinyl acetate, 5,500 IU; cholecalciferol, 550 IU; alpha-tocopheryl acetate, 30 IU; menadione, 4.4 mg; riboflavin, 11 mg; d-pantothenic acid, 22.05 mg; niacin, 30 mg; cyanocobalamin (vitamin B_{12}), 33.0 µg.
[b]Supplied per kilogram of diet: Cu (as $CuSO_4 \cdot 5H_2O$), 10.5 mg; I (as $Ca(IO_3) \cdot H_2O$), 0.26 mg; Zn (as ZnO), 125 mg; Fe (as $FeSO_4 \cdot H_2O$), 125 mg; Mn (as MnO), 30 mg; Se (as Na_2SeO_3), 0.3 mg.
[c]Calculated composition.
[d]ME = Metabolizable energy.

concentration increased regardless of lysine source. Gilts were leaner than barrows (P < 0.01). Total lysine intake increased with increasing dietary lysine in both sources of lysine (P < 0.01). Pigs that were fed individually consumed more total lysine than pigs fed in groups (P < 0.05). Pigs fed individually receiving the diet supplemented with 0.30% lysine from the crystalline source consumed 0.30 g/d less than pigs fed the diet supplemented with the same amount of lysine from SBM (P < 0.10). There was a diet × week interaction (P < 0.01) for PUC. The PUC decreased for pigs consuming crystalline-supplemented diets and increased for pigs consuming SBM-supplemented diets during the 4-wk experimental period. The results indicate no significant differences in growth performance and carcass traits of pigs fed supplemented diets from L-lysine•HCl and soybean meal, suggesting that the efficiency of lysine utilization from SBM-bound lysine is similar to crystalline lysine.

Introduction

A previous experiment conducted with nursery pigs indicated that the efficiency of lysine utilization from crystalline lysine or in soybean meal was similar. However, these results may not apply to the growing phase, because additional factors such as the type of intake (restricted or *ad libitum*), individual or group feeding, and sex differences may affect the efficiency of lysine utilization. Several studies have evaluated the effect of stocking density on the responses of growing pigs to dietary lysine. It has been reported that there are no interactions between dietary lysine concentration and individual vs group feeding on growth traits. However, individually penned animals had greater feed intakes and growth rate than groups-penned animals.

Another factor that requires special attention when evaluating lysine utilization is the variation associated with sex. Gilts and barrows have a different pattern of lean and fat deposition. Gilts require greater dietary amino acid concentrations than barrows, and probably both sexes differ in the efficiency of amino acid utilization. Based on these observations, and considering the differences in the growth response observed in pigs fed individually or in groups, a study was designed to determine the efficiency of utilization of crystalline lysine relative to the lysine in soybean meal for growth in barrows and gilts individually fed or fed in groups.

Procedures

Animals and Facilities

This study consisted of two experiments replicated in time. One hundred twelve (112) growing pigs (56 barrows and 56 gilts; average initial body weight of 39.6 lb) were used in each experiment. There were two rooms with 28 pens each. Each pen contained a nipple waterer and a one-hole feeder. There were 56 gilts (14 individually penned and 42 in 14 pens with three pigs/pen) and 56 barrows (14 individually penned and 42 in 14 pens with three pigs/pen) used in the feeding experiment. There were two replications per treatment in each experiment for a total of four replications.

Dietary Treatments

Diets were limiting only in lysine. For the 28-day experiment, pigs were allowed ad libitum access to the seven experimental diets and water. The seven diets used (Table 1) consisted of a basal diet (0.55% lysine) and diets containing 0.65, 0.75, and 0.85% total lysine that were achieved by adding lysine to the basal diet from either soybean meal (SBM) or L-lysine•HCl (crystalline). Tryptophan, methionine, and threonine were added to the diets to meet the requirements for these amino acids in the basal diet and to the other diets to provide an amino acid pattern relative to lysine similar to the pattern in the basal diet.

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Growth Performance and Carcass Traits

Pigs and feeders were weighed weekly to determine average daily gain (ADG), average daily feed intake (ADFI), and feed efficiency (ADG/ADFI). Total lysine intake (TLI) and supplemental lysine intake (SLI) were estimated based on ADFI and analyzed lysine concentration of the diets. At the end of the experiment (week four), all pigs were scanned using real-time ultrasound to measure tenth-rib backfat depth and longissimus muscle area (LMA). These measurements were used to calculate the fat-free lean gain (FFLG) using the National Pork Producers Council prediction equation.

Blood Samples

Blood samples were taken from 28 pigs at the beginning of each experiment and from all pigs weekly (weeks one, two, three and four). These samples were collected in heparinized evacuated tubes and put in ice. Plasma was separated by centrifugation and frozen at 0 °F until analysis for plasma urea concentration.

Statistical Analyses

The treatment design was 2 × 3 × 2 × 2 + 4 factorial arrangement of treatments: 2 lysine sources (SBM and L-Lysine•HCl) × 3 lysine concentrations (0.65, 0.75, and 0.85%) × 2 sexes (barrows and gilts) × 2 feeding methods (group and individual) + 4 (basal diets). Growth performance data were analyzed as a split-plot in time with repeated measurements in time. Pen was considered the experimental unit. Carcass data were analyzed as a complete randomized design. Linear contrasts were used to compare the five dietary treatments. The contrasts were: basal diet vs the other diets and comparisons between lysine supplemented from crystalline lysine vs soybean meal at the lysine concentrations of 0.65%, 0.75%, and 0.85%, respectively.

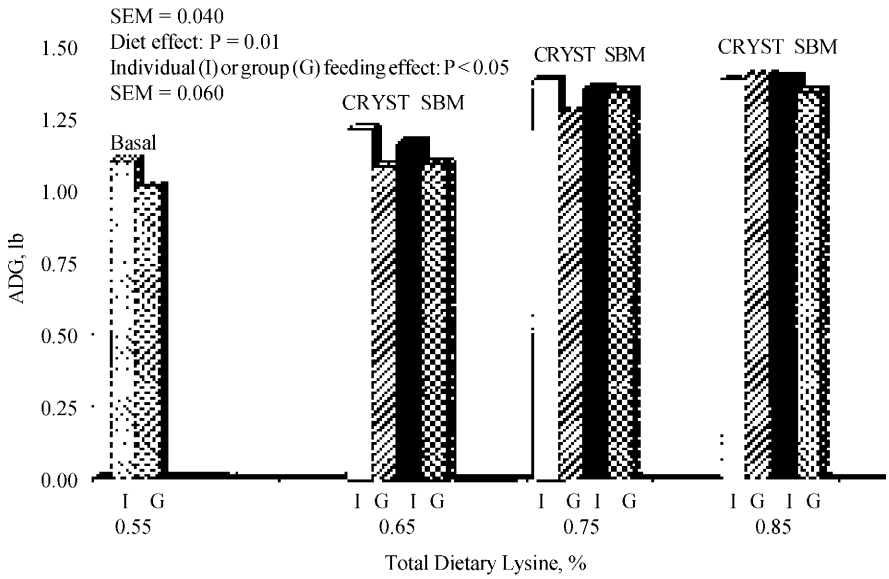

Figure 1. Response of average daily gain (ADG) to experimental diets in pigs fed individually (I) or in groups.

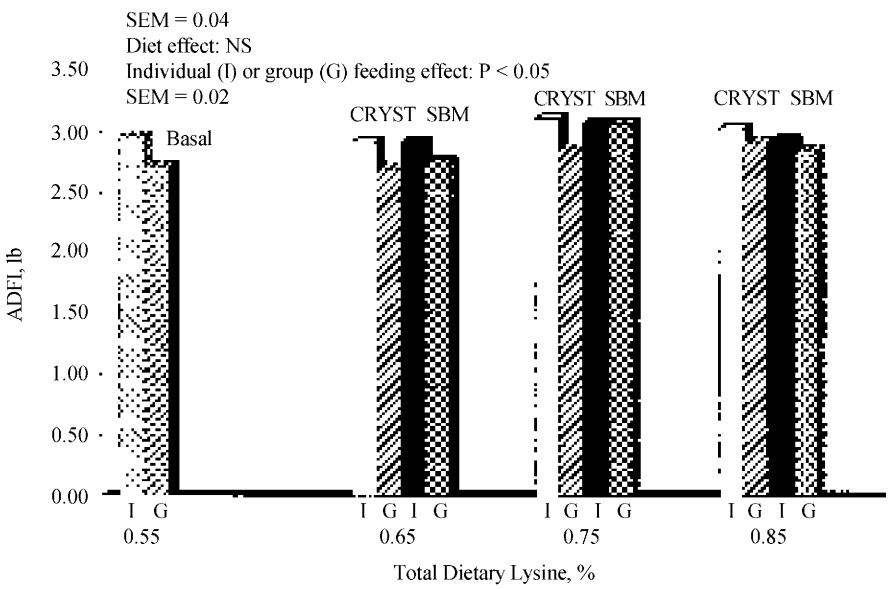

Figure 2. Response of average daily feed intake (ADFI) to experimental diets in pigs fed individually (I) or in groups (G).

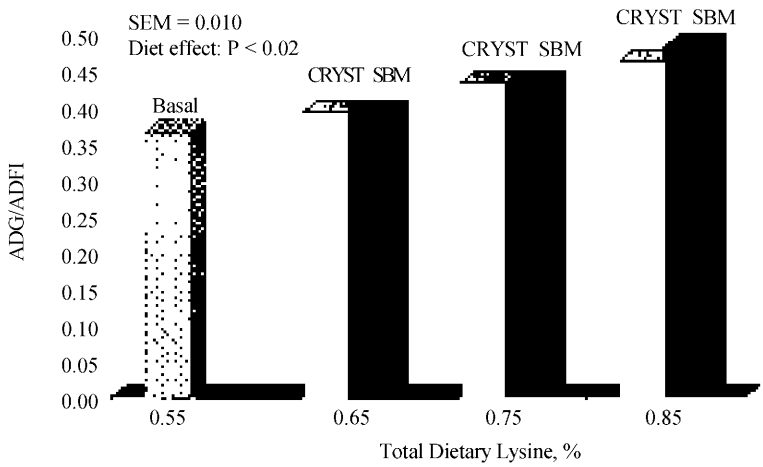

Figure 3. Overall response of feed efficiency (ADG/ADFI) to experimental diets.

Table 2.The response of body weight and carcass traits to dietary treatments.

Source	BASAL	CRYSTALLINE			SOYBEAN MEAL				P-Value		
Lysine, %	0.55	0.65	0.75	0.85	0.65	0.75	0.85	SEM[a]	Diet[b]	Basal vs others[c]	CRYST vs SBM (0.85%)[c]
Item											
Initial BW[d], lb	41.25	40.80	41.19	40.50	40.47	41.96	40.68	0.818	NS	NS	NS
Final BW, lb	71.50	73.77	79.14	80.50	72.06	80.72	79.75	1.624	< 0.01	< 0.01	NS
Backfat depth, in	0.40	0.40	0.40	0.38	0.39	0.40	0.37	0.011	NS	NS	NS
LMA[e] in^2	1.88	2.08	2.23	2.44	1.99	2.21	2.28	0.050	< 0.01	< 0.01	< 0.05
FFLG[f], lb/d	0.44	0.51	0.59	0.67	0.49	0.59	0.63	0.015	< 0.01	< 0.05	NS

[a]SEM = Standard error of the mean.
[b]Significance of main effect.
[c]Significance of contrasts. CRYST = crystalline lysine and SBM = lysine from soybean meal.
[d]BW = Body weight.
[e]LMA = Longissimus muscle area.
[f]FFLG = Fat-free lean gain calculated as: Final fat-free lean gain – Initial fat-free lean gain[g].
[g]Initial fat-free equation: $\frac{0.95 * [-3.65 + (0.418 * \text{live weight , lb})]}{28 \text{ d}}$

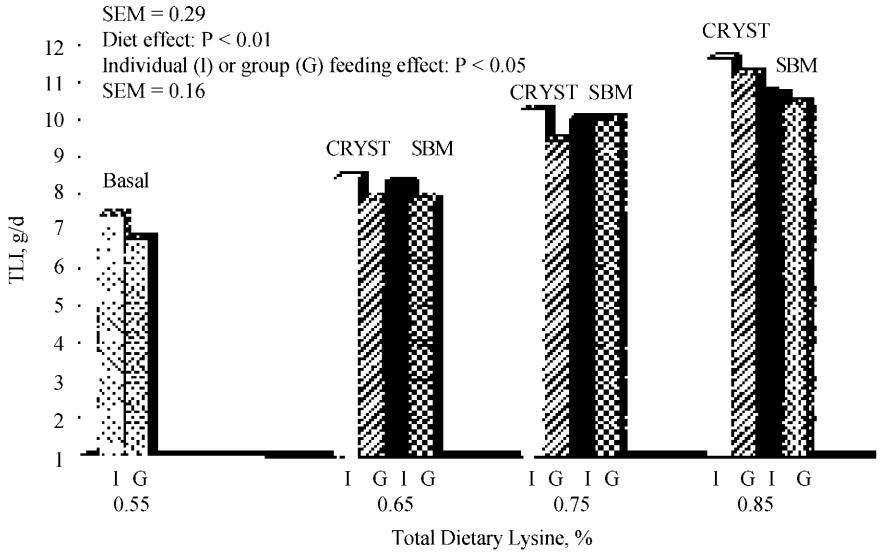

Figure 4. Response of total lysine intake (TLI) to experimental diets in pigs fed individually (I) or in groups (G).

Results and Discussion

Growth Performance

Average daily gain was affected by dietary lysine concentration (P < 0.01) but was similar for both sources of lysine (Figure 1). Pigs fed individually had a greater ADG than pigs fed in groups (P < 0.05). No differences among dietary treatments (P > 0.10) were observed in ADFI (Figure 2). However, pigs fed individually had a greater ADFI (P < 0.05) compared with pigs fed in groups (3.0 lb vs 2.8 lb, respectively). Feed efficiency increased as the lysine concentration in the diet increased (P < 0.01; Figure 3). Pigs fed individually or in groups had a similar feed efficiency. Linear contrasts indicated no differences between pigs fed crystalline lysine and lysine from soybean meal for feed efficiency. Growth performance criteria were similar between barrows and gilts (P > 0.10).

Carcass Traits

Carcass traits are shown in Table 2. Pigs fed the basal diet had the lowest final body weight (BW) (P < 0.01). There were no differences in backfat depth of pigs fed the seven dietary treatments (P > 0.10). However, LMA increased (P < 0.01) as the lysine concentrations increased for both lysine sources. Gilts had a greater LMA (P < 0.01) than barrows. There was a similar LMA for both lysine sources at the 0.65 and 0.75% lysine concentrations. However, pigs fed the diet supplemented with 0.30% crystalline lysine (0.85% total lysine) had 0.16 in^2 greater LMA than pigs fed the same percentage of lysine from SBM (P < 0.05). Fat-free lean gain increased (P < 0.01) as the dietary lysine concentrations increased for both lysine sources in a similar manner. Gilts were leaner than barrows (P < 0.01).

Lysine intake

As expected, TLI increased with increasing dietary lysine (P < 0.01; Figure 4). Pigs fed the basal diet had a lower TLI than pigs fed the other six dietary treatments (P < 0.01). The TLI was 0.85 g/d more for pigs fed diets supplemented with 0.30% crystalline lysine (0.85% total lysine) than in pigs fed the SBM at the same lysine concentration (P < 0.05). Pigs that were fed individually consumed 0.47 g/d additional total lysine than group-fed pigs (P < 0.05). There was a significant interaction of diet × individual or group feeding (P < 0.10) for SLI (Figure 5). Pigs fed individually receiving the diet supplemented with 0.30% lysine from the crystalline source consumed 0.30 g/d less vs pigs fed the diet supplemented with

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the same amount of lysine from SBM ($P < 0.10$).

Plasma Urea Concentration

There was a diet × week interaction ($P < 0.01$) for PUC (Figure 6). The PUC decreased for pigs consuming crystalline-supplemented diets and increased for pigs consuming SBM-supplemented diets during the four-week experimental period.

Discussion

Growth Performance

The results indicate no significant differences in growth performance and carcass traits of pigs fed lysine deficient diets supplemented with lysine using L-Lysine•HCl and soybean meal in growing pigs between 41 and 77 lb body weight. The increasing responses in ADG and feed efficiency indicate that the diets were limiting in lysine. These responses were similar for both sources. All diets were formulated to be limiting in lysine because the efficiency of utilization of amino acids consumed depends on whether lysine intake is limiting or in excess. Excess of dietary lysine will be preferentially used for energy and be used at a reduced efficiency for muscle growth. Dietary treatments did not affect ADFI, indicating that pigs had a similar feed intake regardless of the dietary source, dietary lysine concentration, or sex. However, the usual response when pigs are fed individually or in groups was observed. In this study, pigs fed individually had a greater feed intake than pigs fed in groups (n = 3).

Carcass Traits

Backfat thickness was not different among treatments, indicating that fat deposition was similar among pigs regardless of lysine source, lysine concentration, sex, and, individual or group feeding. Differences in LMA between pigs fed crystalline-supplemented diets and pigs fed SBM-supplemented diets at the highest dietary lysine concentration may be attributed to greater carcass leanness as lysine approached the requirement.

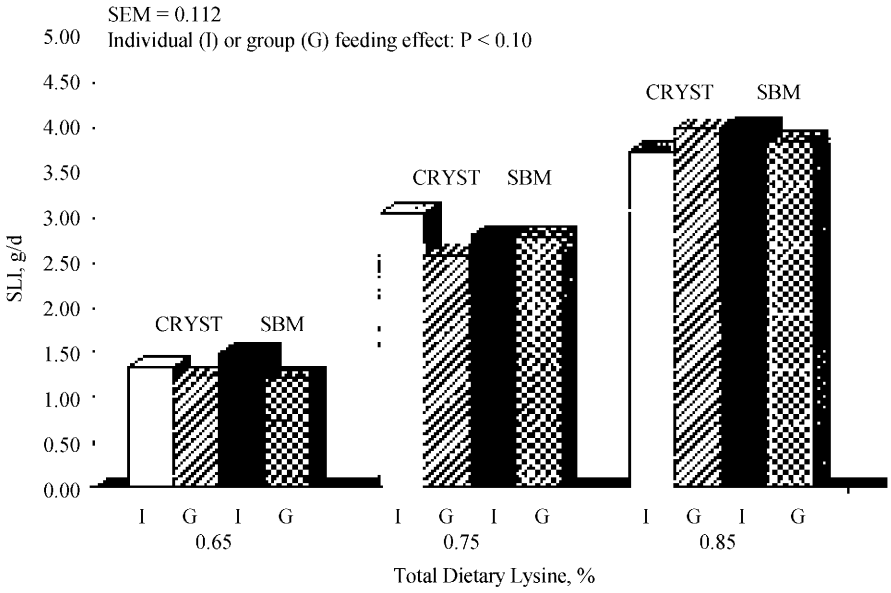

Figure 5. Response of supplemental lysine intake (SLI) to experimental diets in pigs fed individually (I) or in groups (G).

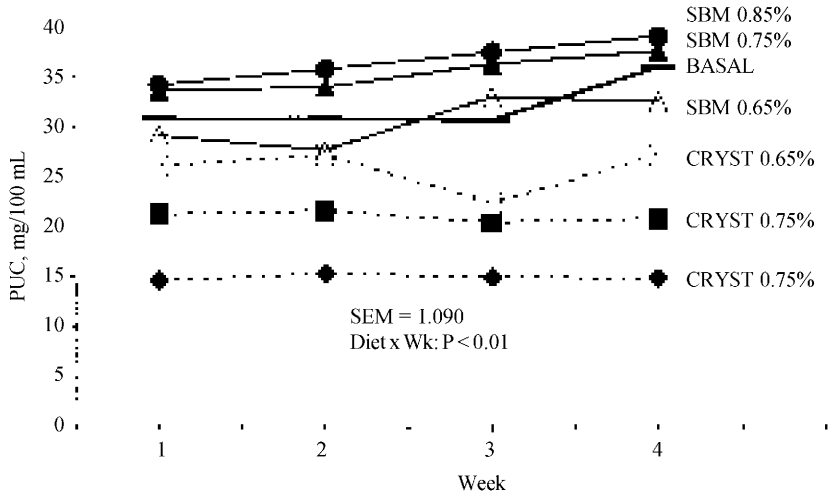

Figure 6. Response of plasma urea concentration PUC) to experimental diets by week.

Lysine Intake. The differences observed in TLI between crystalline or SBM-bound lysine were observed only at the highest lysine concentration (0.85% lysine). The increased TLI was greater for pigs fed the crystalline-supplemented diets and is attributed to an increase in feed intake. The SLI represents only the portion of intake due to the supplemental lysine from either crystalline or SBM additions to the basal diet.

Plasma Urea Concentration

A reduction in PUC has been previously determined in pigs fed concentrations of crystalline lysine below the requirement. The decrease in PUC concentration for diets with increasing additions of L-lysine•HCl indicated that lysine was deficient throughout the range of diets fed. The increased PUC in the SBM-supplemented diets presumably reflected the greater crude protein content in these diets as the dietary lysine concentrations increased to achieve the same concentrations of the crystalline-supplemented diets. Also, crystalline

amino acids were added to these diets to maintain a similar ratio of essential amino acids relative to lysine in all dietary treatments, which may increase PUC.

Conclusions

The results from this study indicate that when pigs are given *ad libitum* access to feed there are no differences in growth performance between pigs fed diets supplemented with L-Lysine•HCl and lysine from SBM. The majority of the studies indicate that protein-bound lysine in SBM is highly absorbed and utilized when compared with other protein sources. A relatively reduced efficiency of utilization of crystalline lysine has been attributed to the rapid absorption of crystalline amino acids relative to amino acids derived from intact protein. However, according with those results, reduced efficiency of utilization resulting from differences in time course of absorption between protein-bound and crystalline lysine probably do not occur when pigs are allowed *ad libitum* access to feed. Some studies have reported that pigs fed SBM-supplemented diets had a greater ADG and improved feed efficiency than pigs fed crystalline-lysine supplemented diets. However, these differences between the two sources seem may be attributable to differences in gut fill, because such differences were not detected on the basis of carcass weight. Therefore, according to the response in growth and carcass traits reported from this study, a further study is needed to determine protein deposition in pigs fed crystalline and SBM-supplemented diets. We are now studying the lysine utilization for protein deposition in these pigs. Results from this study will determine whether lysine from both sources is absorbed and utilized with the same efficiency.

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[1]Janeth J. Colina is a graduate student, Phillip S. Miller is an associate professor, Austin J. Lewis is a professor emeritus, and R. L. Fischer is a research technologist in the Department of Animal Science.